

Detection of tumor mass based on laser scanning imaging

Munqith S. Dawood
Department of biomedical
Engineering
Al-Nahrain University
monkithsdz51@yahoo.com

Eman Ghadhban Khalil
Department of Biomedical
Engineering
Al-Nahrain University
dr.emankhalil@yahoo.com

Halah Hadi Saleh
Department of biomedical
Engineering
Al-Nahrain University
eng.hala85@yahoo.com

Abstract:

Optical methods are widely used for medical diagnostic and therapeutic purposes. The use of laser source as non-ionized radiation in the imaging is considered safe, and has advantages more than the other radiological methods. The laser application in imaging is based upon the detection and measuring the laser light parameters after passing through the turbid media of the tissue layers and the tumor mass to differentiate them precisely according to their different optical properties.

In this experimental study, the tumor masses were implanted in the legs of ex-vivo mice. Then each leg was non-invasively scanned by NIR 785nm diode laser. The penetrated laser light power through the leg was measured. The results were tabulated and treated by using the Matlab program version R2013a (8.1.0.609) to create 2D image for the scanned tissue. The resulted images were clear. They showed precisely the imbedded tumor, its dimensions, and its location inside the tissue.

Keywords: laser scanning; NIR laser; laser imaging.

1. Introduction:

There are different methods used for Tumor detection and imaging such as radiography, computed tomography scan (CT-scan), mammography, magnetic resonance imaging scan (MRI), ultra-sound and optical imaging etc. [1-8]. Nowadays the lasers used in many different and interesting medical diagnostic applications, such as monitoring of blood oxygenation and tissue metabolism, as well as the laser imaging for tumor mass detection. All these applications depend upon the measurements of the changes in the optical physical parameters due to the interactions between the laser light and tissues layers [9-13].

In this practical study, a non-invasive laser imaging technique is implemented to detect the presence of cancer mass inside the tissue. Laser scanning and detection setup has been assembled to detect and illustrate the presence of tumor, its size and location inside the scanned tissues of the ex-vivo mice.

2. Materials and methods:

2.1 Laboratory animals

Twenty eight (BALB/C) mice of ages 4-6 weeks and weight between 19-24g were used in this study.

A tumor mass of about 0.5cm^3 was implanted subcutaneously inside their legs as shown in figure (1).



Figure 1: The tumor implantation process in the mouse leg.

2.2 Scanning technique

The laser scanning was carried out to create 2D images of the tumor inside the mice tissues.

NIR diode laser light source Edmund type model no. 59-086 of 5 mw output and 785 nm wavelength was used to illuminate the tumor mass within the tissue. The transmitted laser light through the scanned tissues was captured by the photo detector head of the Gentec laser power meter on the opposite side of the tissue.

Figure (2) shows the whole experimental setup with the used laser power meter and its photodetector head.

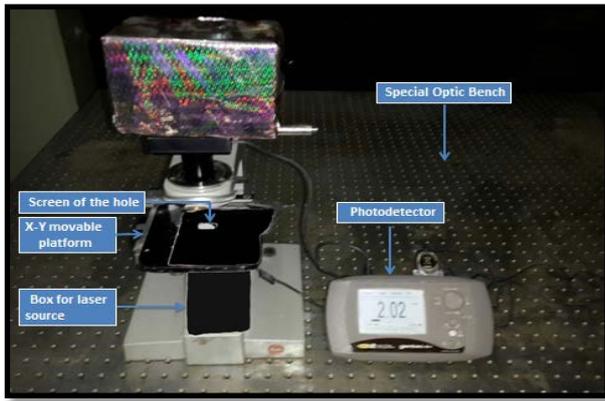


Figure 2: The experimental setup.

A screen with a suitable hole was used to fix the boundaries of scanned area by the laser. The scan was performed horizontally and the received laser power was measured and recorded at each 1mm distance along the scanned x-axis tissues. Then they were repeated for each 1mm pitch distance(d). The scanning procedure is presented in the schematic diagram shown in fig. (3). The mouse laid on the setup platform as shown in figure (4).

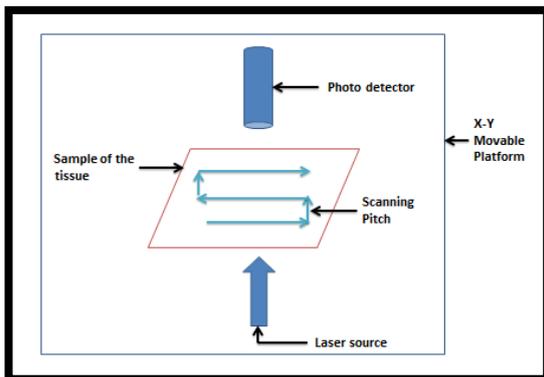


Figure 3: Schematic diagram of the scanning procedure.

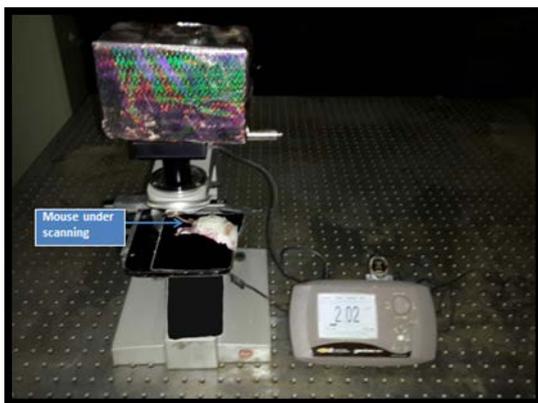


Figure 4: The mouse laid on the scanning Platform.

The recorded power measurements were tabulated and fed to the computer, and were processed by using the Matlab program version R2013a (8.1.0.609) to create the image of the tumor mass inside the normal tissue depending on the tabulated measured laser powers for each mouse.

3. Results:

From the twenty eight scanning results of the implanted tumor samples in mice ,only one group of the results is selected and presented in table (1). This table is used to create the laser scanning images for the implanted tumor mass in the mice by using MATLAB program version R2013a (8.1.0.609). Each color in the images was specified to indicate a narrow band of the detected and measured laser powers, which passed through different tissues layers in the mouse legs.

The blue colors used to illustrate the bone and the tumor mass. Both of them are highly absorbers and permit low powers of 1 mW or less. The red color presents the higher received laser powers of 2mW or more. The graduated colors between them, which ranged from 1mW to 2mW assigned to indicate the other powers due to presence of other tissue layers. The resulted images are shown in figs (5 - 12).

Table 1: The results of the measured laser power out of the scanned mouse leg

Pitch distance (d) steps in mm.	The measured laser power in mW at each 1 mm along the horizontally x –axis scanned tissue														
	1	2.32	2.3	2.29	2.29	2.29	2.29	2.29	2.31	2.31	2.31	2.32	2.33	2.35	2.34
2	2.13	2.16	2.18	2.21	2.22	2.25	2.27	2.3	2.31	2.31	2.32	2.33	2.35	2.34	2.32
3	1.11	1.07	0.609	1.33	1.37	1.64	1.75	1.93	2.11	2.23	2.31	2.33	2.34	2.34	2.3
4	0.07	0.3	1.7	0.31	0.35	0.46	0.66	0.99	1.35	1.74	2.02	2.19	2.27	2.34	2.26
5	0.5	0.501	0.516	0.53	0.511	0.462	0.13	0.3	0.48	0.81	1.13	1.5	1.77	1.97	1.97
6	0.511	0.51	0.51	0.52	0.51	0.52	0.471	0.41	0.433	0.463	0.511	0.5	0.55	0.75	0.71
7	0.5	0.53	0.51	0.54	0.53	0.65	1	1.3	1.5	1.44	1.23	1.11	1.2	0.9	0.54
8	0.51	0.511	0.16	0.24	0.66	1.12	1.47	1.76	1.82	1.77	1.57	1.35	1.17	1.5	0.9
9	0.7	0.66	1.1	1.56	1.86	2.14	2.25	2.28	2.28	2.24	2.17	2.09	1.96	1.62	1.2
10	1.31	1.71	2.13	2.23	2.28	2.28	2.3	2.3	2.31	2.32	2.32	2.26	2.17	2.05	2
11	2.06	2.22	2.28	2.28	2.28	2.29	2.3	2.3	2.31	2.32	2.32	2.31	2.35	2.33	2.34
12	2.27	2.28	2.28	2.28	2.28	2.28	2.29	2.3	2.31	2.32	2.32	2.31	2.35	2.33	2.34

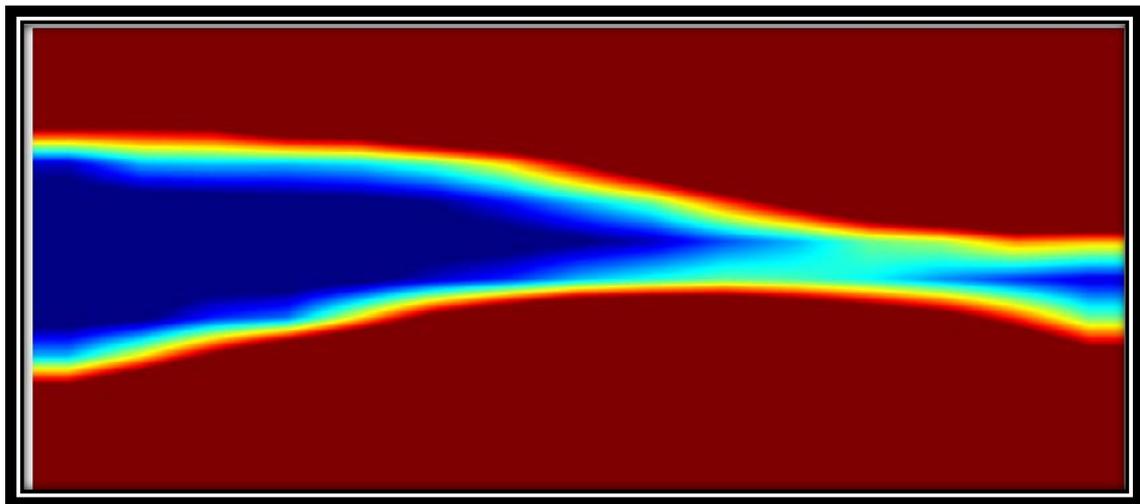


Figure 5: The colored image of the mouse leg (thigh and knee) before tumor implantation. The skin appears in red color and the bones appear in dark blue color.

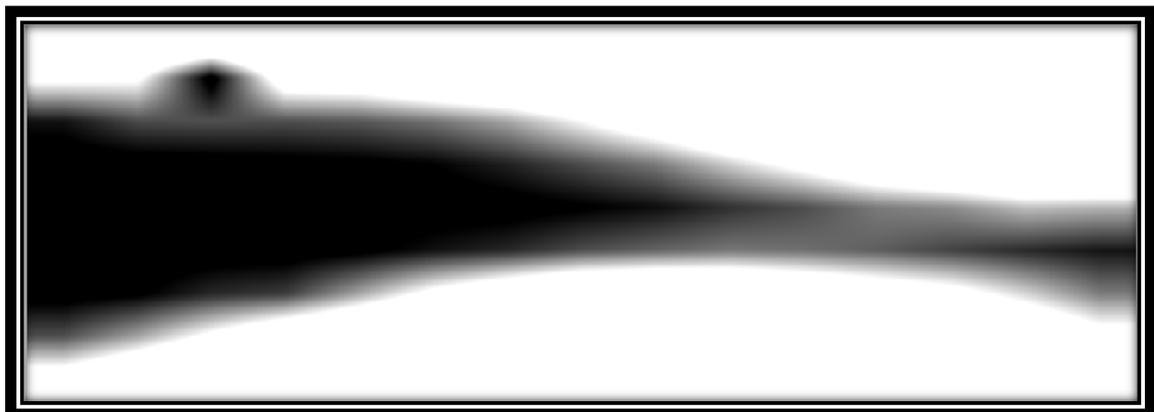


Figure 6: Black and white image tones of the mouse leg after implanting the tumor mass.

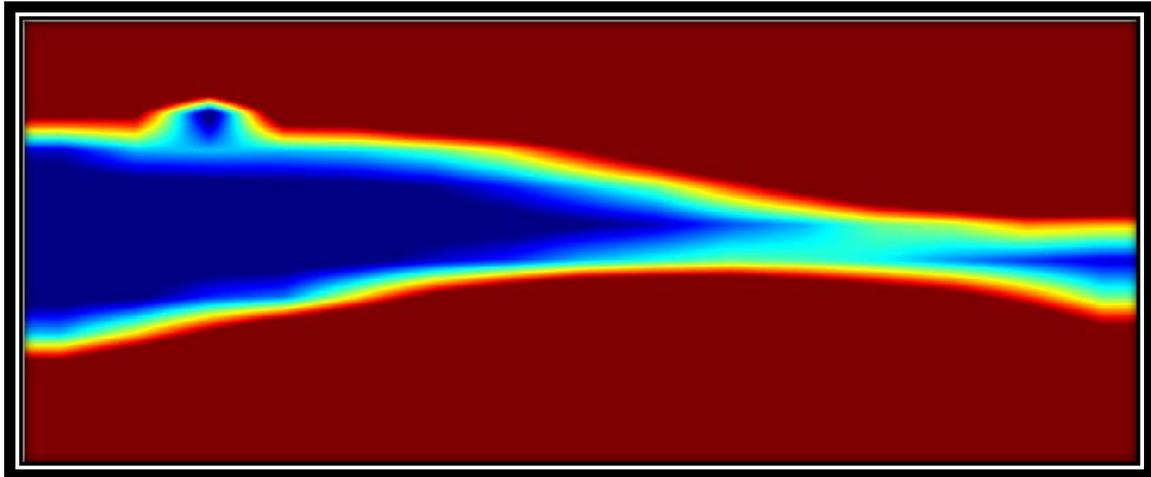


Figure 7: Colored image of the mouse leg after implanting the tumor mass.

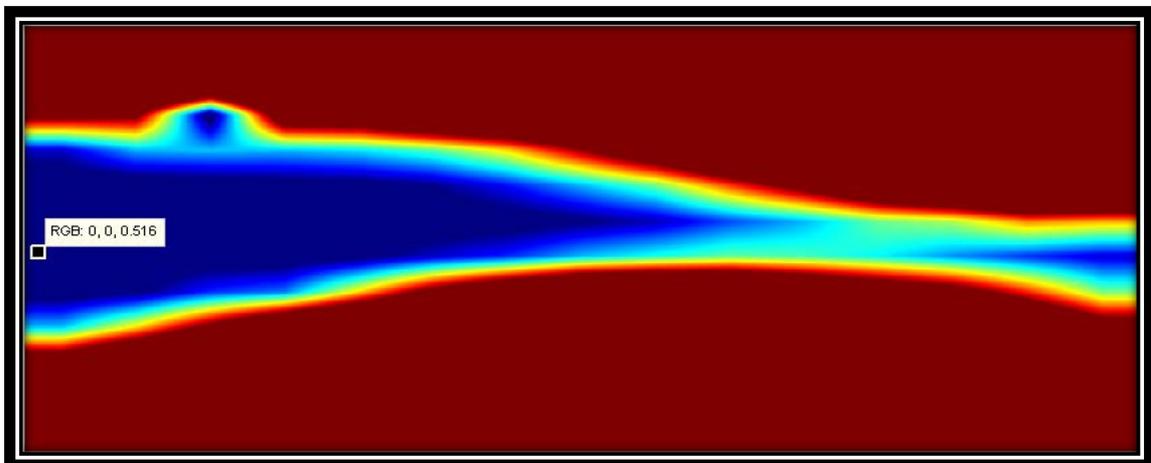


Figure 8: The value of the received laser intensity in mW after passing through the bone and tumor is shown on the blue area inside the rectangular window of the mouse thigh image.

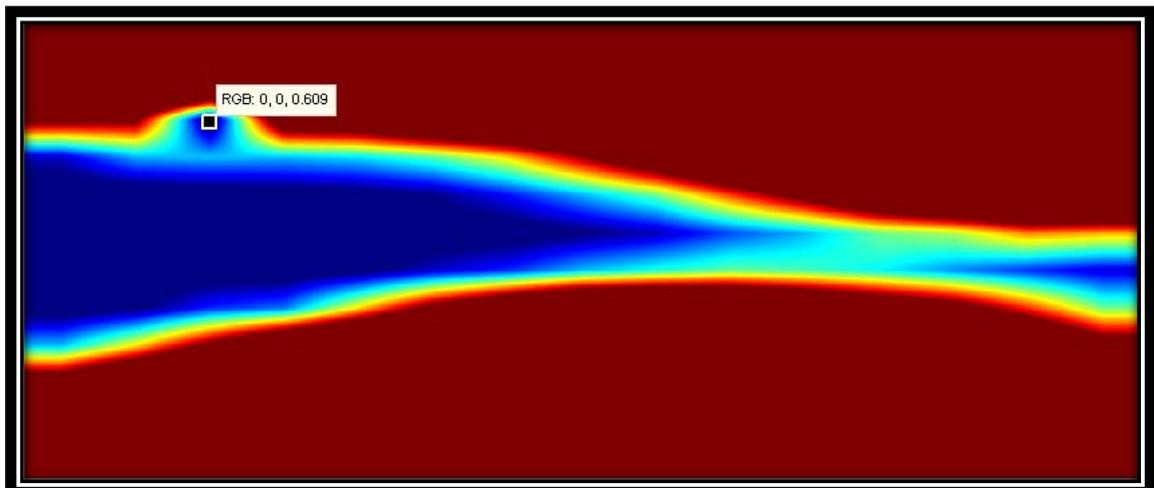


Figure 9: The value of the received laser intensity in mW after passing through the tumor is presented inside the rectangular window on the tumor area image.

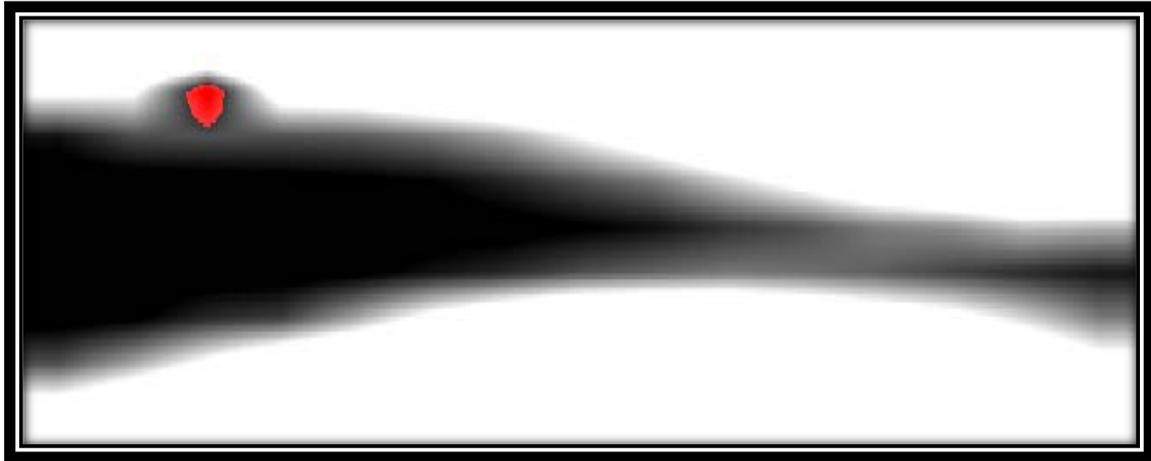


Figure 10: Distinguishing the tumor shape and size.

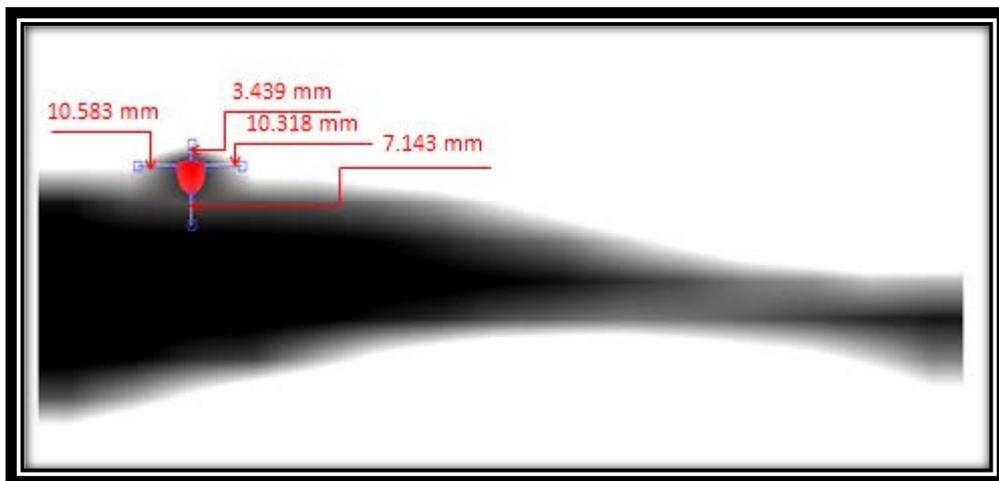


Figure 11: The location coordinates of the tumor inside the leg tissues. Its distances from the skin surface and underlie bone are successfully measured.

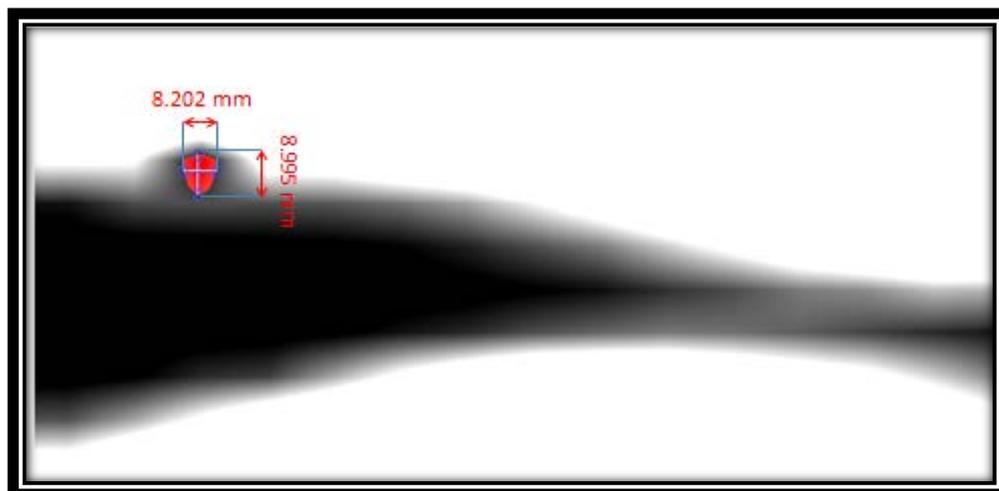


Figure 12: Image of the real dimensions of the tumor mass.

4. Discussion:

This study manifests the laser scanning imaging technique as a simple, easy and non-invasive method. The laser imaging considered safe due to the non ionizing nature of the laser source.

The contrast of the created image depends on the difference in the optical properties of the different tissues layers; the normal tissues and abnormal tissues (the implanted tumor mass). Single NIR laser wavelength was used to create the image and determine the tumor position.

In both of the achieved black–white and colored images, the graduation of colors depends on the amount of total attenuation of laser (reflection, absorption and scattering) passing through different healthy and tumor tissues layers.

The differences in the optical properties of the tumorous tissues and the normal surrounding tissues, lead to receiving different laser powers on the other side of the scanned area consequently, different colors appear in the constructed image due to the different tissues layers in the scanned area.

These practical results appear in agreement with studies of Brian W et al., Victorcheromordik et al., Sergio Fantini et al., and T. Durduran et al., [14-17].

In this experimental work the low cost and low power 785 nm diode laser was used in illuminating and scanning the tissue due to its deeper penetration as it is in the near infrared band (NIR) and because it is still slightly visible. This visibility made it easier to control the manual scanning operation.

In agreement with the findings of Mohammed Mesradi et al., in 2013, who showed clear differences between fresh and frozen tissues optical properties, therefore, in our study the scanning was performed immediately after killing the mice by anesthetic material to get more realistic results and images.

In our work the tissue was scanned along the X and Y axes (d pitch distance) to create the 2D image, while Durduran et al., in 2002 [17] used the parallel plate transmission geometry to create the image.

5. Conclusions:

In conclusion, this technique proved the capability and efficiency of the laser scanning and imaging as diagnostic tool for tumor mass detection. It could be used as a support to confirm the early detection and diagnosis of tumors *in-vivo*.

This application is useful also to determine the location, size, depth and the distances between the tumor and the surrounding tissues and organs.

The accuracy and clarity of the created image is highly proportional to the type of used laser and to its spot size as well as to the optical tissue parameters.

This method is safe to monitor and evaluate the changes in the tumor size (growing or regression) *in-vivo* during the treatment. So the patients' response to the therapy can be evaluated (therapy response monitoring).

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كشف كتلة الورم باستخدام التصوير بالمسح الليزري

هاله هادي صالح

د. ايمان غضبان خليل
جامعة النهدين / كلية الهندسة
قسم هندسة الطب الحيوي

د. منقذ سليم داود

الخلاصة

ان للتصوير البصري بالليزر العديد من المزايا التي تتفوق على التصوير باستخدام التقنيات الإشعاعية الأخرى بسبب كون الليزر المستخدم هو مصدر إشعاع غير مؤين. وتستند هذه الطريقة على كشف توزيع ضوء الليزر في اوساط الأنسجة العكرة بصريا وتمييزها بدقة حسب الخصائص البصرية لكل نسيج. وفي دراستنا العملية هذه تم اجراء المسح الضوئي الليزري للنسيج باستخدام مصدر دايود ليزر 785 نانومتر ومقياس يقيس قدرة الليزر بعد نفاذها خلال النسيج لتكوين صورة ثنائية الأبعاد باستخدام برنامج الماتلاب. وتم تصوير كتلة ورم سرطانية مزروعة تجريبيا في الفئران مباشرة بعد قتلها اعتماداً على الاختلافات في الخصائص البصرية والقدرة المستلمة من الليزر التي مرت خلال كتلة الورم المزروعة والأنسجة الطبيعية المحيطة بها، وبذلك تم كشف وتحديد الموقع والحجم وعمق كتلة الورم في النسيج باستخدام تقنية المسح بالليزر كوسيلة غير نافذة دون الحاجة الى التدخل الجراحي.